Correlation of Pre-Operative Cancer Imaging Techniques with Post-Operative Gross and Microscopic Pathologic Images

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Abstract: during this first year, different algorithms for volume reconstruction from tomographic slices have been tested. A tissue-mimicking phantom made with a mixture of agar and aluminium oxide was sliced at different thicknesses as per pathological standard guidelines. Phantom model was also virtually sliced and reconstructed in software. Results showed that shape-based spline interpolation method was the most precise, but generated a volume underestimation of 0.5%. Nearest neighbour interpolation produced the most accurate values.

OCIS codes: (170.3880) Medical and biological imaging; (100.6950) Tomographic image processing

1. Introduction

The current study aims to retrospectively bridge the gap between post-operative pathology and diagnostic imaging, by fusing pathological findings to pre-operative PET-CT scans. The challenges of this study are the disparity in image resolution between modalities and the non-linear deformations undergone by lung tissue during the different clinical stages. During this first year, simulations with a synthetic phantom have been used to test several volume reconstruction algorithms and methods.

2. Materials and methods

Several synthetic tissue-mimicking phantoms have been used to test the performance of the different algorithms implemented in this project. Materials tested include poly(vinyl alcohol) and agar gelatine, the latter showing the most appropriate mechanical properties for our purpose. Aluminium oxide is added as scattering agent to make the material opaque in the x-ray spectrum. A custom-designed mould has been 3D-printed to produce the phantom samples.

Two different interpolation algorithms have been tested to reconstruct the phantom volume from discrete tomographic slices. The first, proposed by Raya and Udupa [1], is based on the distance transform applied on the shape boundary. After interpolating the missing slices, a threshold is applied to the resulting volume, so that any voxel with a value greater or equal to zero corresponds to the volume. The resulting mesh is then smoothed using the algorithm proposed in [2], to remove any noise introduced during slice segmentation.

The second interpolation method is based on morphology filters, defined in [3,4]. It consists of evolving the shape in slice i using erosion/dilation operators constrained by the mask in slice $i+1$. This approach is better suited for handling topology changes between slices, which is especially important around the model's extrema.

3. Results

Several agar phantoms were physically sliced at 2.5 and 5.0 mm intervals. For each slice, the phantom area was segmented using a self-implemented region growing algorithm. Interpolation was performed with a cubic spline function. The volume recovered on all experiments laid between 92% and 93% of the ground truth value. Shape-wise, high frequency features were better reconstructed after slicing at 2.5 mm intervals, as expected.

The slicing procedure was also simulated in software, and the phantom was reconstructed from the subset of slices. Thicknesses of 1.0, 2.5 and 5.0 mm were produced, introducing a random offset to the first cut, and nearest neighbour, linear and spline interpolation methods were tested. After running the experiment 200 times for each setup, results showed that spline interpolation gives the highest precision in terms of overall volume recovered, whereas nearest neighbour produces the most accurate values (99.97%).

Future work will focus on producing new phantom models with different shapes, to assess the statistical robustness of the results obtained. We also plan to compare our reconstruction method against commercial software used in radiotherapy planning, as well as testing our pipeline on human tissue.

4. References

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